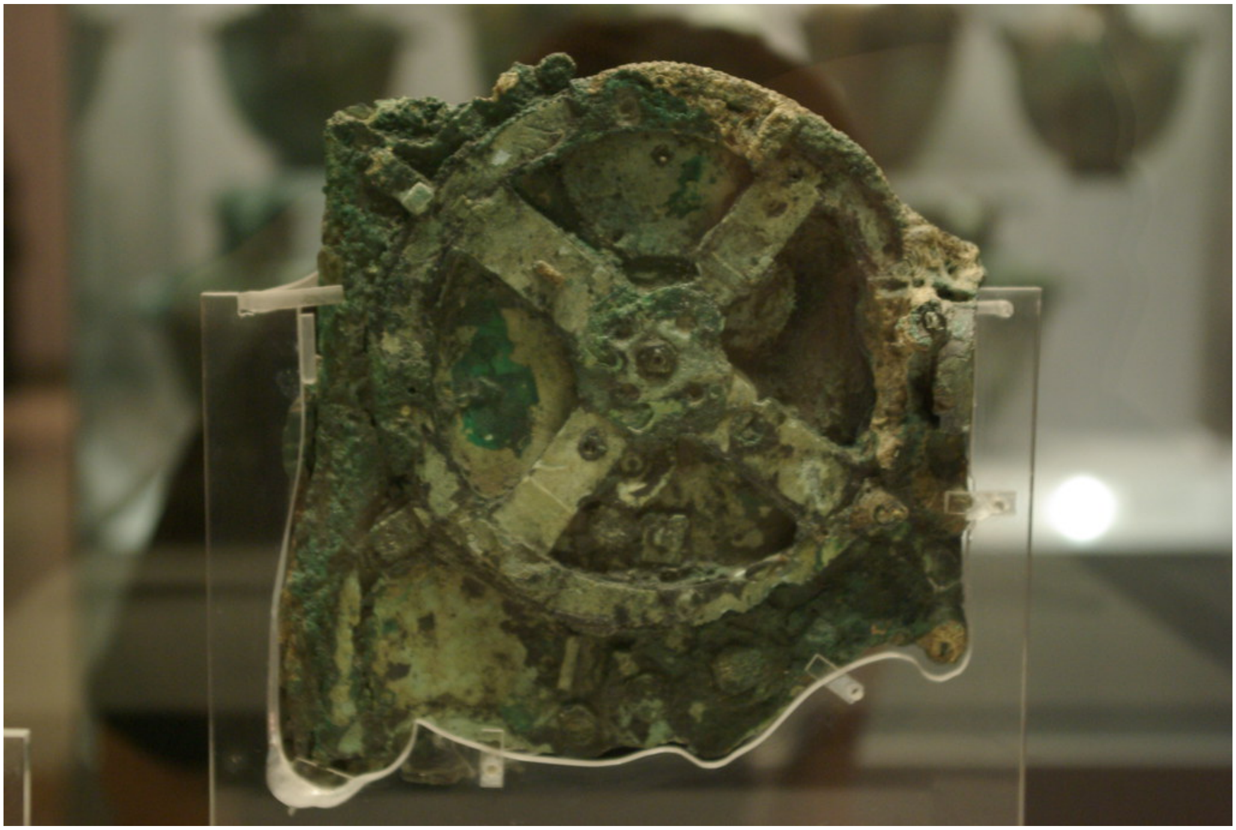
2.3: The Greeks

2.3.1 The Early Greeks

Until the fourth century BCE, ancient people mainly focused on documenting patterns in the sky and making predictions. Then the Greeks became the first people to devise a model that explained the motions of the Sun, the Moon, and the planets. Much of their models were guided by their belief that the Heavens were perfect, as opposed to the imperfect world around them. They saw the circle and the sphere as the most perfect shapes and therefore, assumed that the celestial bodies were perfect spheres and orbited in perfect circles. This philosophical assumption became so ingrained in Western thought that it was only until the late sixteenth/early seventh centuries that astronomers like Kepler and Galileo (See Chapter 3) began to question it.

The classical revolution in Greece became around 700 BCE. Much like the Babylonians and Egyptians, the Greeks were mainly using astronomy to make predictions, often using techniques imported from those countries. For example, in his writings, Hesiod describes using the appearance of the Pleiades star cluster as the time to harvest crops.

The Greeks also refined a lot of the mathematical techniques employed by the Babylonians. They even developed mechanical calendars and calculators for use in navigation and astrology. One example was the **Antikythera Mechanism**. This was discovered in 1901 in ancient shipwreck. Constructed sometime between 150-100 BCE, it could calculate the position of the Moon, planets, and stars for a given date.

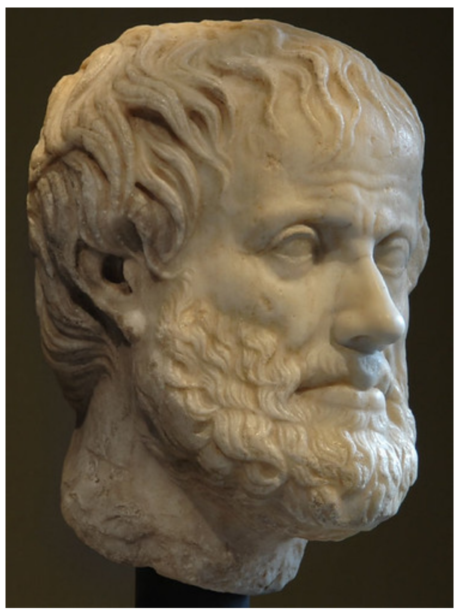


This mechanical calculator was used for navigation and making astronomical observations by the Ancient Greeks.

"Antikythera Mechanism" by LoboEstepario is licensed under CC BY-NC 2.0;

By 500 BCE, the mathematician Pythagoras determined that the Earth was a sphere and that the Morning Star and the Evening Star were both the planet Venus. Later in the fifth century BCE, Anaxagoras of Clazomenae deduced the cause of lunar eclipses being the Moon passing through the Earth’s shadow. Given the curved nature of the shadow as it moved across the face of the Moon, Anaxagoras was also able to determine that the Earth is a sphere. He also studied a meteorite and guessed that the Sun was an incandescent stone larger than all of Greece, which resulted in him being banished for impiety.

2.3.2 Aristotle



"Head of Aristotle. Vienna, Museum of Art History, Collection of Classical Antiquities." by Sergey Sosnovskiy is licensed under CC BY-SA 2.0;

In the fourth century BCE, Aristotle (382-322 BCE) published his philosophical writings that would become some of the most influential treatises in Western thought for centuries. Aristotle wrote that the Earth was a sphere at the center of the universe. He concluded the edge of the universe to be a literal sphere upon which held the “fixed” stars that revolved around the Earth. The Sun, the Moon, and the planets (wandering stars) each had their own spheres that also revolved around the Earth.

2.3.3 Heliocentrism v. Geocentrism

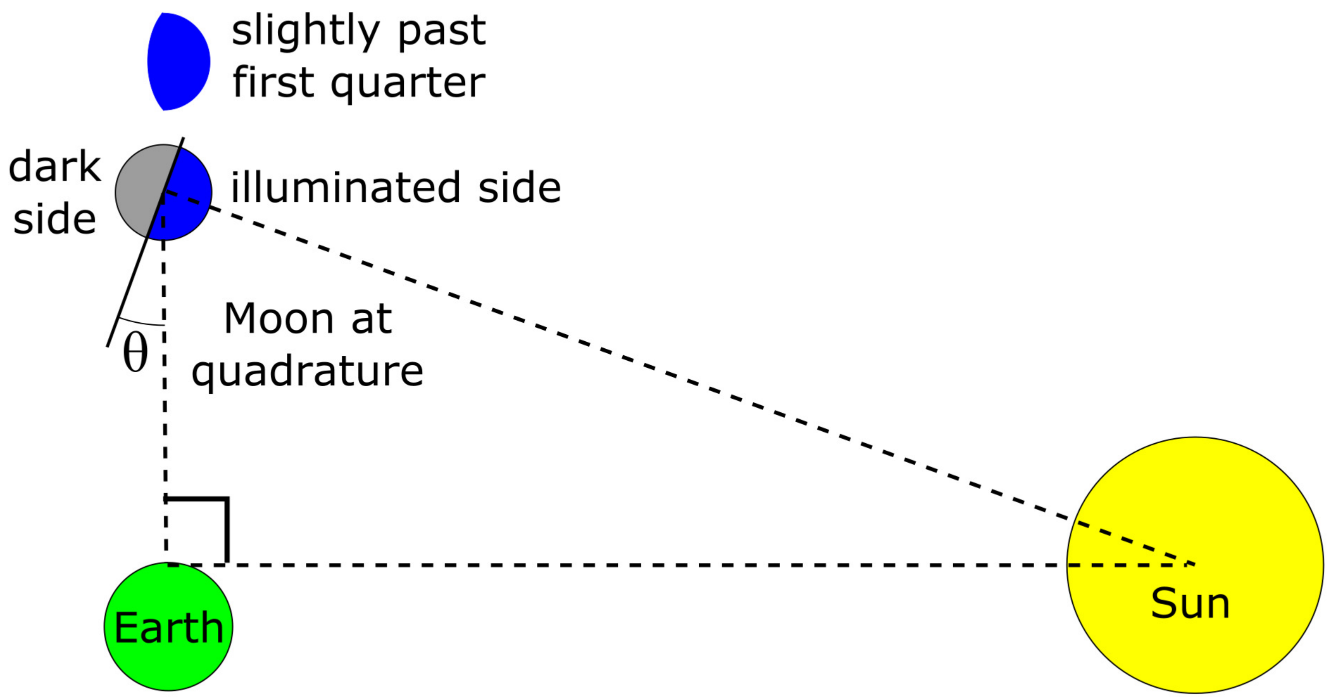
Around 360 BCE Eudoxus also described a model for the stars and planets. Like Aristotle, Eudoxus held to a **geocentric** (Earth-centered) model in which the complex motions of the planets could be explained as perfect circular motion consisting of 27 nested spheres, all revolving around the Earth.

Not all the Greeks held to a geocentric model. Aristarchus (310-230 BCE) took careful measurements to determine the relative distances and sizes of the Sun and the Moon. He determined that the Moon is about 1/3 the size of the Earth and that the Sun was at least 20 times farther away from the Earth than the Moon. He also estimated that the Sun was seven times larger than the Earth. He also deduced that the Moon shone because it reflected light from the Sun. Though his numbers were off, his insight that the Sun was larger than the Earth convinced Aristarchus that the Sun should be the center of universe. He viewed the Sun as the “king” sitting on its throne around which the planets, including the Earth, and all the stars revolved. This is the first known example of a **heliocentric** (sun-centered) cosmology.

A heliocentric model, however, predicts that the stars should exhibit parallax (Chapter 1) and Aristarchus could not detect any measurable parallax using the techniques available of his time. He therefore concluded that the stars had to be very far away, and that the universe was much bigger than assumed in Aristotle’s geocentric cosmology. He wrote that the stars were distant suns like our own and that if we were able to view them up close, they would be as big and bright as the Sun.

Most of his contemporaries, however, rejected Aristarchus’ heliocentric model in favor of Aristotle’s geocentric one. They had several objections, including the lack of parallax. If the Earth moves, why don’t we perceive it? Why don’t dropped objects fly off into the west? Why don’t we fly off the surface? Why are tall buildings not being toppled by this motion? The most important objection, however, was that a heliocentric model based on perfect circles did not make any more accurate positions about the movement of the planets than a geocentric model did. It would take nearly a thousand years for people like Kepler, Galileo, and Newton to devise a better understanding of the motion and gravity before any of these objections could be overcome (Chapter 3).

Erastothenes (276-195 BCE) Was able to use measurements of shadows to calculate the circumference of the Earth. He noticed that the Sun was at his zenith in the city of Syene on the summer solstice. In Alexandria, the Sun was seven degrees from the zenith on the same day. From this, he deduced that the two cities were seven degrees apart on the spherical Earth. Knowing the distance between the cities, he calculated the circumference of the Earth as 42,000 km, which is fairly close to the actual figure of 40,000 km.



Aristarchus used triangulation to determine the Sun was much larger and much further away from the Earth than the Moon.

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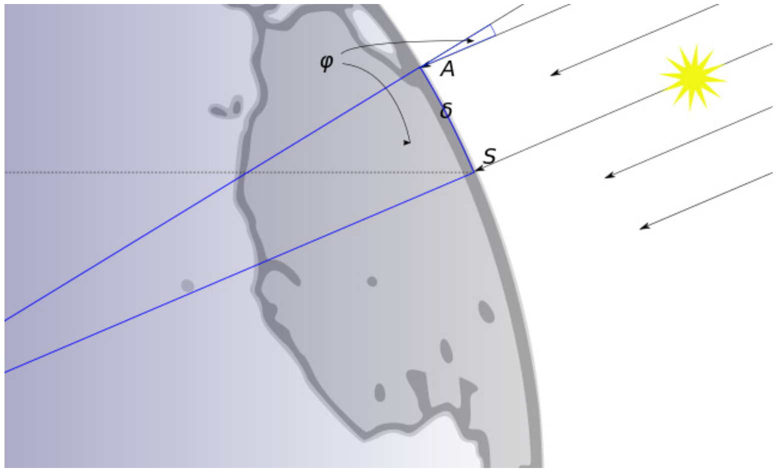

By measuring the differences in the angle of the Sun made on the Summer Solstice between Syene and Alexandria, Erastothenes was able to calculate the circumference of the Earth.

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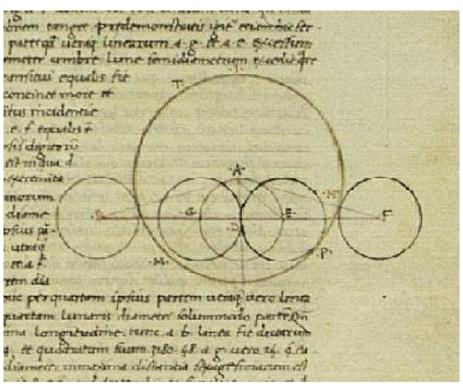
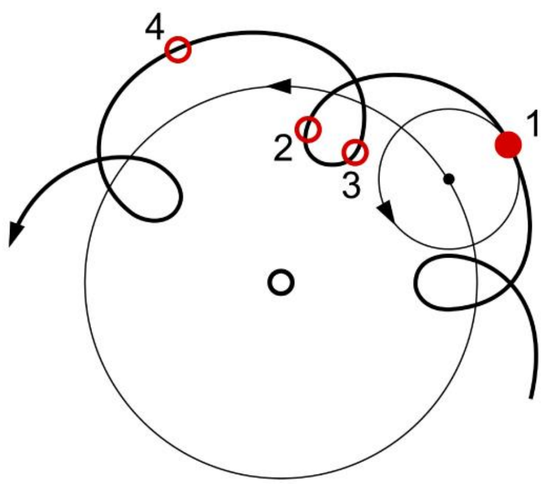
Sometime around 180 BCE, Hipparchus introduced a system of celestial coordinates and his star maps containing 850 stars. Using naked-eye sighting instruments to aid in his observations, Hipparchus created a magnitude system in which he described the brightest stars as first magnitude, the next brightest stars as second magnitude. His convention on brightness, with refinements from modern instruments, is still used by astronomers today. Hipparchus may also have been the first to use trigonometry in his studies of astronomy. Some scholars even credit him with inventing trigonometry. He also discovered the precession of the Earth's axis. Using the most precise measurements available in his time, Hipparchus tried to find evidence of stellar parallax. Not being able to detect any, he argued in favor of the geocentric model supported by Aristotle and Eudoxus.

Ptolemy (85-165 CE), the last great astronomer of the classical period, summarized all of the previous knowledge of Greek astronomy in his work, **Almagest** (Arabic for "The Greatest Work"). Ptolemy also refined the earlier epicycle/deferent model by introducing the **equant**. In Ptolemy's model, the planets, Sun, Moon, and stars all still revolved in perfect circles, but the Earth was move slightly off center. Instead, the celestial spheres all revolved around the equant, a point some distance away from the center of the Earth.



A Page from Ptolemy's Almagest.

Ptolemy/Public domain;



Epicycles were used to explain the retrograde motion of planets like Mars

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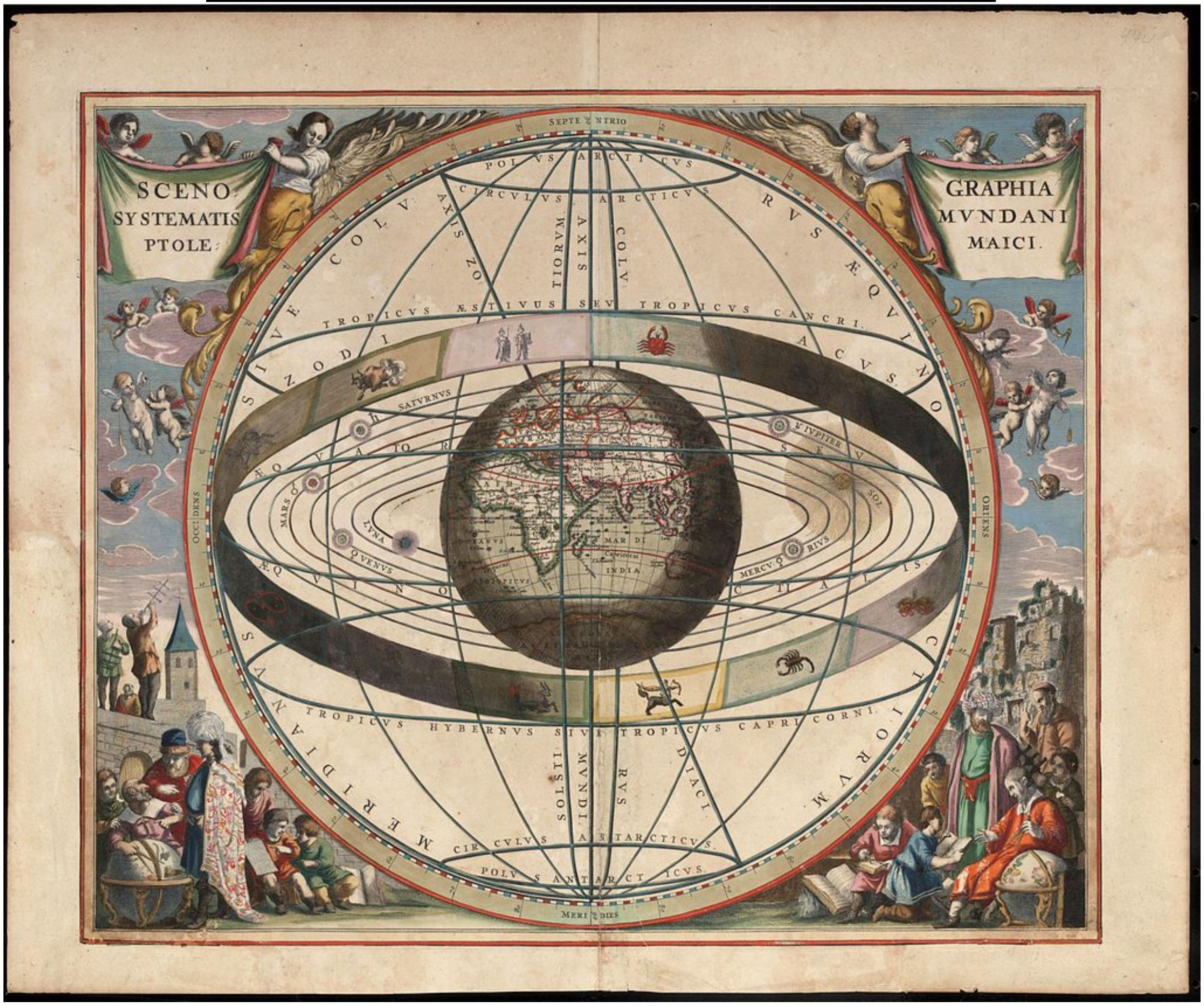

The Ptolemaic System. Jan van Loon/Public domain;